

Amendments to the Specification

Please insert the following paragraph on page 1 beginning at line 3.

This is a continuation of United States patent application Serial No. 10/012,799 filed November 3, 2001; which is a continuation of application Serial No. 09/403,121 filed February 23, 2000 that issued March 19, 2002, as United States Patent no. 6,357,164 B1; which was filed pursuant to 35 U.S.C. § 371 claiming priority from Patent Cooperation Treaty ("PCT") International Patent Application No. PCT/US98/07848 which was published 22 October 1998, under International Publication No. WO 98/46070.

Please replace the paragraphs that respectively begin on page 3 at line 20, page 4 at line 36, and page 5 at line 15 with the following amended paragraphs.

~~Briefly, the present invention improves upon the basic discovery disclosed in the PCT patent application that individual bars of a mesh cell can be formed to act as mini hydrofoils in field operations. During field operations in a water entrained environment, the trawl disclosed in the PCT patent application becomes disposed symmetrically about a central axis. The disclosed trawl~~

~~includes a plurality of mesh cells, each mesh cell having at least three mesh bars. Each mesh bar in the trawl intersects with at least one other mesh bar. During field operations with the trawl in a water entrained environment, at least a portion of at least one of the mesh bars of at least one of the mesh cells in the trawl exhibits a substantial hydrofoil like effect that aids in increasing a performance characteristic of a trawl system. That portion of mesh bars in accordance with the present invention which exhibit a substantial hydrofoil like effect is preferably formed from a material that has a substantially incompressible cross-sectional shape, is offset from the central axis of the trawl, and is formed with a hydrofoil shape that:~~

- ~~1. has a lay with a loose, corkscrew shaped pitch establishing a corkscrewing groove that provides cambered sections; and~~
- ~~2. is oriented to establish leading and trailing edges for that portion of mesh bars which exhibit the hydrofoil like effect.~~

~~The lay of that portion of mesh bars which exhibit the hydrofoil like effect has an orientation relative to a receding direction, and the leading edge for that portion of mesh bars which exhibit the hydrofoil like effect, when normalized to the receding direction relative to the central axis, resides at a side of the mesh bar. Pairs~~

~~of lay and the leading edge are selected for mesh bars from a group consisting of:~~

- ~~1. a left hand lay, and the leading edge being a right side of the mesh bar as viewed in the receding direction; and~~
- ~~2. a right hand lay, and the leading edge being a left side of the mesh bar as viewed in the receding direction.~~

~~If the lay and leading edge are selected from the preceding group, then movement of the mesh bar in accordance with the present invention through the water entrained environment relative to a water flow vector that is neither parallel nor perpendicular to the mesh bar creates a pressure differential across that portion of mesh bars which exhibit the hydrofoil like effect. The pressure differential thus created across such mesh bars establishes a lift vector relative to the central axis of the trawl, most commonly directed away from the central axis of the trawl. Consequently, the lift vector created by movement of the mesh bars which have a portion that exhibit the hydrofoil like effect increases the performance characteristic of the trawl which is selected from a group consisting of substantially increased trawl volume (particularly in shallow water) in comparison with a trawl made from conventional mesh, improved trawl shape, and reduced vibration, noise, and drag.~~

~~Various other aspects of the present invention further improve the performance of trawl systems. Thus, properly controlling the shape, arrangement, and distribution of strands assembled to form a mesh bar further improves a trawl in accordance with the present invention. The proper pitch for the loose, corkscrew shape is advantageously controlled so the pitch of each mesh bar is in a range of $3d$ to $70d$, with a range of $5d$ to $55d$ being preferred, where d is:~~

- ~~1. for a pair of twisted strands forming a mesh bar, the diameter of the smaller strand of the pair;~~
- ~~2. for mesh bars that include more than a pair of twisted strands or strands of differing diameters, the diameter of the next to largest diameter twisted strand; or~~
- ~~3. for straps forming a mesh bar, the width of the strap.~~

~~Within the preferred pitch range, a pitch of $5d$ to $15d$ generally produces maximum lift for mesh bars formed from product strands, while a pitch of $25d$ to $55d$ generally produces minimum drag for mesh bars formed from product strands.~~

~~For mesh bars formed by straps, a pitch of $8d$ to $30d$ generally produces maximum lift, while a pitch of $9d$ to $21d$ generally produces minimum drag. A ratio for the~~

~~width of the strap to a thickness of the strap is preferably in a range of 1.5:1 to 20:1. Straps for which the ratio is in a range from 2.5:1 to 2.75:1 provide both low drag and good lift. Straps for which the ratio is in a range from 2.75:1 to 10.0:1 provide high lift. Straps for which the ratio is in a range from 1.8:1 to 2.5:1 provide low drag with good lift. Straps for which the ratio is in a range from 1.5:1 to 1.8:1 exhibit lower drag. Straps in the range from 1.8:1 to 2.5:1 may be used advantageously in the mid section and/or back end of the trawl. Conversely, straps in the range from 2.75:1 to 10.0:1 may be used advantageously in the front end, particularly near a leading edge of the trawl. in one aspect is a trawl assembled from a plurality of mesh cells. Each mesh cell includes at least three mesh bars. At least one portion of at least a first mesh bar in at least one of the mesh cells includes a first product strand having a core product strand enclosed within a sheath. The sheath is specifically formed to resist sliding along the core product strand during assembly and field operations of the trawl. The first product strand forming the first mesh bar is also mechanically connected to a second product strand forming a second mesh bar of the at least one mesh cell. The mechanical connection specifically includes a clamp which encloses at least the slide-resistant, sheathed portion of the first product~~

strand. In this way the sheathed portion of the first product strand disposed within the clamp resists separation of the sheath from the core product strand during trawl assembly and field operations thereby better preserving design characteristics of the first mesh bar and the trawl.

In one aspect, a thread, having a particularly preferred embodiment of the sheath, forms the first product strand of a trawl in accordance with the present invention. The particularly preferred embodiment for the sheath includes at least one spiraling product strand interwoven with other encircling product strands of the sheath. In this preferred embodiment, the spiraling product strand has a diameter that is larger than a diameter of each of the other encircling product strands.

In another aspect, the present invention is also an improved method for catching fish with a trawl system. The method includes a step of assembling the trawl system by combining components selected from a group consisting of a trawl, upper bridles and frontropes. The improved method for catching fish also includes deploying into a body of water as part of the trawl system the sheathed, first mesh bar from a vessel disposed on the surface of a body of water, and propelling at least the sheathed, first mesh bar through the body of water.

Please replace the paragraph that begins on page 12 at line 8 with the following amended paragraph.

It should be pointed out that product strands are synthetic or natural fibers or filaments which are preferably but not necessarily the product of a conventional manufacturing process, usually made of nylon, polyethylene, cotton or the like twisted in common lay direction. Such strand can be twisted, plaited, braided or laid parallel to form a sub-unit for further twisting or other use within mesh bars 35 in accordance with the teachings of the present invention and the PCT patent application. In general, bonded product strands exhibit significantly greater hydrodynamic lift, e.g. a 1.3 to 1.7 or greater increase in lift, than unbonded product strands of identical diameter. To minimize drag while maximizing hydrodynamic lift a densely laid, heat set and bonded product strand, densely braided product strand, or strap, each of which has a substantially incompressible cross-sectional shape and a somewhat roughened surface, is preferred for preserving, during and after assembly of the trawl 13 or 283, the profile and configuration of the mesh bars 35 and 283, as well as that of the cambered sections created by the loose, corkscrew-shape, particularly upon application of tensile forces to mesh bars 35 and 283. Alternatively, in applications where maximizing hydrodynamic lift is a primary consideration and breaking

strength and drag requirements are easily satisfied, bonding may be used to make product strands or straps substantially incompressible while reducing manufacturing cost. Bonding resists a tendency for product strands or straps to compress during assembly and field operations, and therefore better preserves designed hydrofoil characteristics of the mesh bars 35 and 283. Variations in applying a bonding material during assembly of mesh bars 35 further permits controlling their external shape and filling gaps between product strands. A urethane polymeric material, or material having similar properties, is adequate as a bonding material.

Please replace the paragraph that begins on page 13 at line 34 with the following amended paragraph.

FIG. 11 illustrates one possible cross-sectional configuration for the strap 284. The configuration depicted in FIG. 11 is basically a parallelogram with diametrically opposite corners 84a being truncated while diametrically opposite corners 284b have pointed edges. Sides 284c are approximately of equal length. The loose, corkscrew-shaped pitch is directly related to the length between opposite corners 284a, i.e the width of the strap 284. Generally, for generating hydrodynamic lift and reducing drag a densely constructed strap 284, formed from a densely woven and bonded strap material, having a

substantially incompressible cross-sectional shape and a somewhat roughened surface is preferred. Variations in applying a bonding material permits controlling the external shape of a strap. A urethane polymeric material, or material having similar properties, is adequate as a bonding material.

Please replace the paragraph that begins on page 15 at line 3 with the following amended paragraph.

In FIG. 17, strap 284"" is triangular in cross-section including sides 425 and hypotenuse 426 opposite of right angle γ . Since the side 425a is longer than side 425b, the cross-section is termed "asymmetric".

Please replace the paragraph that begins on page 15 at line 18 with the following amended paragraph.

FIGS. 23a through 23c depict various "S" or "Z" cross-sectional shapes that provide improved performance when used for the straps 284 of mesh cells 280. As depicted in FIGS. 23a-23e, the "S" or "Z" cross-sectional shapes for the straps 284 add a drooping leading edge 338 and a raised trailing edge 339 to the rectangular cross-sectional shape of a conventional strap. During testing, twisted straps 284 having a cross-sectional shape such as those illustrated in FIGS. 23a-23e have exhibited greater

hydrodynamic lift and lower drag than a simple, rectangularly-shaped strap 284.

Please replace the paragraph that begins on page 17 at line 12 with the following amended paragraph.

FIGS. 20a and 20b depict alternative embodiments of the parallelogram-shaped strap 284 depicted in FIG. 20. As with the strap 284 depicted in FIG. 20, the straps 284 depicted in FIGS. 20a and 20b are respectively assembled by laminating together two (2) and four (4) individual, rectangularly shaped straps 304. Even in the absence of twisting, parallelogram-shaped straps 284 such as those depicted in FIGS. 20, 20a and 20b create a hydrodynamic lifting force that is approximately one-half of the lifting force for the same strap when twisted. The direction of the hydrodynamic lifting force, i.e. horizontally to the left or right in FIGS. 20a and 20b, depends upon the relationship between the laminated straps 304 and the direction of water flow.

Please replace the paragraph that begins on page 19 at line 17 with the following amended paragraph.

In the method illustrated in FIGS. [23 and 24] 22 and 23, the straps 332 twist in opposite directions on opposite sides of the pins 334. FIG. 25 illustrates an alternative method for assembling smaller mesh cells 280

for the [for the] trawl 263 in which straps 332 extend straight along a line that slopes upward from left to right (indicated by broader lines), or downward from left to right, indicated by narrower lines). Straps 332 that extend in such straight lines have only a single, uniform direction of twist along their entire length, rather than an alternating direction of twist which changes at each of the pins 334s in FIGS. 23 and 24. Similar to the assembly method described for FIGS. 23 and 24, the method of depicted in FIG. 25 juxtaposes short sections 336 of two adjacent straps 332. Correspondingly, the smaller mesh cells 280 are then fixed by laminating together the short sections 336 in the manner described above.

Please replace the paragraph that begins on page 19 at line 32 with the following amended paragraph.

FIGS. 26a and 27a illustrate straps 284 having symmetrical, angled shaping strips 372 disposed along both a first edge 374 and a second edge 376 of straps 284. As is apparent from the illustrations, the shaping strips 372 alternately project from one side surface 382 and then an opposite side surface 384 of the strap 284. Moreover, the shaping strips 372 wrap around either the first edge 374 or the second edge 376 in passing from one surface 382 to the other surface 384. Properly orienting and positioning the shaping strips 372 projecting from

one surface 382 or 384 of the strap 284 with respect to twisting of the straps 284 aligns that portion of the shaping strip 372 on the cambered section substantially parallel to water flow past the mesh bar 283 while the portion of the shaping strip 372 on the other side 384 or 382, which extends between a pair of immediately adjacent cambered sections, is oriented substantially perpendicular to water flow. The straps 284 that include the shaping strip 372 exhibit greater hydrodynamic lift, improved hydrodynamic characteristics under larger twisting pitches, and increased twisting stability. The shaping strips 372 may be formed in various ways such as by stitching. FIGS. 26b and 27b illustrate straps 284 for which shaping strips 372 disposed along the first edge 374 are formed with a different angle from the shaping strips 372 disposed along the second edge 376 of straps 284.

Please replace the paragraph that begins on page 20 at line 32 with the following amended paragraph.

While for maximizing hydrodynamic lift and minimizing drag there exists an ideal orientation for the dashed line 392 indicating the cambered section 394 with respect to the arrowed line 396 indicating the water flow vector, the present invention permits engineering a trawl 13 having nearly maximum lift while minimizing drag even

though the angular relationship between the dashed line 392 and the arrowed line 396 varies. Thus, the arrowed line 396 may be parallel to the dashed line 392, or may be skewed at an angle on either side of the dashed line 392 as will likely occur due to flexing of the mesh cells 30 of the trawl 13 during field operations in a water entrained environment. However, in assembling the trawl 13 or 263 the loose, corkscrew-shaped pitch of the mesh bars 35 is engineered to properly orient the dashed line 392 indicating the cambered section 394 with respect to the anticipated orientation of arrowed line 396 indicating the water flow vector depending upon the location of a mesh cell 30 or 280 within the trawl 13, and upon the hydrodynamic characteristics of particular product strands 36, 37 or straps 284 assembled into the mesh bars 35 or 283.

Please replace the paragraph that begins on page 21 at line 12 with the following amended paragraph.

FIG. 28b depicts a configuration for the product strands 36, 37 in which the product strand 36 spirals around the product strand 37 which is aligned coaxially with the common axis of symmetry 38. Similar to the illustration of FIG. 28a, the dashed line 392 in FIG. 28b indicates the cutting plane through the mesh bar 35 along the cambered section 394 of the mesh bar 35, and the

arrowed line 396 indicates a possible direction of the water flow vector past the mesh bar 35. Also similar to the mesh bar 35 depicted in FIG. 28a, the narrowest width of corkscrew-shaped mesh bars 35 having the configuration illustrated in FIG. 28b at a bottom of grooves 391 measured parallel to the direction of the groove with a conventional vernier caliper approaches a diameter of the largest product strand 36 or 37, and the widest width at the cambered section 394 is substantially equal to the sum of diameters of the product strands 36 and 37. FIG. 28c depicts a configuration for product strands 36, 37 in which [the] a pair of product strands 37 spiral around the product strand 36 which is aligned coaxially with the common axis of symmetry 38. Similar to the illustration of FIGS. 28a and 28b, a pair of dashed lines 392 in FIG. 28c indicate cutting planes through the mesh bar 35 that pass through cambered sections 394, and a pair of arrowed lines 396 indicate possible directions for the water flow vector past different locations along the mesh bar 35. In the forward section 24 of the trawl 13, each mesh bar 35 made of product strands includes a series of at least thirty-five (35) cambered sections 394. In the forward section of the trawl 263, each mesh bar 283 made of straps 284 includes a series of at least twenty-five (25) cambered sections.

Please replace the paragraph that begins on page 22 at line 1 with the following amended paragraph.

One characteristic of the mesh bar 35 depicted in FIG. 28 is that field operations in a water entrained environment [applies] apply a force that urges the product strand 36 to slide along the product strand 37. FIG. 29 depicts a configuration for such a mesh bar 35 which prevents the product strand 36 from sliding along the product strand 37 by including the product strand 36 among strands 397 of a conventional braided sheath 398 that encircles the product strand 37.

Please replace the paragraph that begins on page 22 at line 11 with the following amended paragraph.

For many applications, various embodiments of the structures described above for the mesh bars 35 and 283 may be selected for assembly and arranged to form the trawl 13 or 263 so that hydrodynamic lift generated by mesh bars 35 or 283 is directed substantially uniformly away from the axis of symmetry 32 or 281 of the trawl 13 or 263. This configuration for the mesh bars 35 or 283 yields maximum trawl volume. However, for other fishing conditions the orientation and design of the mesh bars 35 or 283 may be arranged so cumulative lift created by the mesh bars 35 or 283 of the bottom panel of the trawl 13 or 263, while directed away from the axis of symmetry 32

or 281 of the trawl 13 or 263, exhibits a lesser magnitude than cumulative lift created by the mesh bars 35 or 283 of the top panel. In this latter configuration, the trawl 13 or 263 exhibits a net upward lift toward the surface 11 or 261 of the body of water 12 or 262.

Please replace the paragraph that begins on page 22 at line 26 with the following amended paragraph.

Although the present invention has been described in terms of the presently preferred [embodiment] embodiments, it is to be understood that such disclosure is purely illustrative and is not to be interpreted as limiting. Consequently, without departing from the spirit and scope of the invention, various alterations, modifications, and/or alternative applications of the invention will, no doubt, be suggested to those skilled in the art after having read the preceding disclosure. Accordingly, it is intended that the following claims be interpreted as encompassing all alterations, modifications, or alternative applications as fall within the true spirit and scope of the invention.